

What is claimed is:

1. A method of joining a solidifiable liquid polymeric material to a solid material to produce a solid article, the method comprising the steps of:

5 contacting a solid material with a solidifiable liquid polymeric material at an interface between the solid material and the liquid polymeric material;

applying ultrasonic energy so that the energy reaches the interface between the contacting solid material and liquid polymeric material; and

10 forming a joint at the interface by allowing or causing the liquid polymeric material to solidify, to produce a solid article comprising the solidified polymeric material joined to the solid material.

2. A method according to Claim 1 comprising an additional step of positioning the solid material inside a mold before the contacting step, wherein the  
15 contacting step comprises introducing the liquid polymeric material into the mold so that the liquid polymeric material contacts the solid material.

3. A method according to Claim 1 wherein the ultrasonic energy is applied by contacting the liquid polymeric material with an ultrasonic horn near the  
20 interface so that the ultrasonic energy is transmitted through the liquid polymeric material to the solid material at the interface.

4. A method according to Claim 1 wherein the solidifiable liquid polymeric material comprises a solidifiable liquid polymer.

25 5. A method according to Claim 1 wherein the solid material comprises a solid polymer.

6. A method according to Claim 1 wherein the solidifiable liquid polymeric material comprises a molten thermoplastic polymer, wherein the step of solidifying the molten polymer comprises allowing or causing the molten polymer to cool until solid, and the method comprising an additional step before the contacting step of melting the thermoplastic polymer at a temperature not greater than 20°F (11°C) above the melting point of the thermoplastic polymer, wherein the application of the ultrasonic energy provides a joint having greater integrity than a joint formed by the same method without the application of ultrasonic energy in which the thermoplastic polymer is melted at a temperature greater than 20°F (11°C) above the melting point.

7. A method according to Claim 1 wherein the method is part of a process selected from the group consisting of potting, laminating, coating, painting, filling, spraying, and applying.

8. A method according to Claim 1 wherein the ultrasonic energy is applied at a frequency between about 10 kHz and about 100 kHz, at a power level between about 1 watt and about 1000 watts, and for a duration between about 0.5 second and about 60 seconds.

9. A method according to Claim 1 wherein the application of the ultrasonic energy is controlled to form a breakable joint having a yield stress between about 100 psi and about 4000 psi.

10. A method according to Claim 1 wherein the contacting step comprises forming a layer of the liquid polymeric material over the solid material.

11. A method of joining a first solidifiable liquid polymeric material to a second solidifiable liquid polymeric material to produce a solid article, the method comprising the steps of:

contacting the first liquid polymeric material with the second liquid polymeric material at an interface between the first polymeric material and the second polymeric material, where the first polymeric material and the second polymeric material are materials of differing composition;

applying ultrasonic energy so that the energy reaches the interface between the contacting first polymeric material and second polymeric material; and

forming a joint at the interface by allowing or causing the first polymeric material and the second polymeric material to solidify, to produce a solid article comprising the solidified first polymeric material joined to the solidified second polymeric material.

12. A method according to Claim 11 wherein the contacting step comprises introducing the first liquid polymeric material and the second liquid polymeric material into a mold so that the first liquid polymeric material and the second liquid polymeric material flow against each other.

13. A method according to Claim 11 wherein the contacting step comprises extruding the first liquid polymeric material and the second liquid polymeric material so that the extruded polymeric materials contact each other.

14. A method of joining a first material to a second material in a molding process to produce a solid article, the method comprising the steps of:

introducing a first material and a second material into a mold, thereby contacting the first material with the second material at an interface between the first material and the second material, where the first material and the second material are materials of differing composition, and where at least one of the first material and the second material is a solidifiable liquid material;

applying ultrasonic energy so that the energy reaches the interface between the contacting first material and second material; and

forming a joint at the interface by allowing or causing the at least one solidifiable liquid material to solidify, to produce a solid article comprising the solid first material joined to the solid second material.

15. A method according to Claim 14 wherein the first material is a solidifiable liquid material and the second material is a solid material, wherein the solid material is positioned inside the mold before the liquid material is introduced, and wherein the contacting step comprises injecting the liquid material into the mold so that the liquid material flows against the solid material.

16. A method according to Claim 15 wherein the ultrasonic energy is applied by contacting the liquid material with an ultrasonic horn near the interface so that the ultrasonic energy is transmitted through the liquid material to the solid material at the interface.

17. A method of joining a first material to a second material in an extrusion process to produce a solid article, the method comprising the steps of:

extruding a first solidifiable liquid material and a second solidifiable liquid material, thereby contacting the first material with the second material at an interface between the first material and the second material, where the first material and the second material are materials of differing composition;

applying ultrasonic energy so that the energy reaches the interface between the contacting first material and second material; and

forming a joint at the interface by allowing or causing the first material and the second material to solidify, to produce a solid article comprising the solid first material joined to the solid second material.

18. A method according to Claim 17 wherein the first and second materials comprise first and second molten thermoplastic polymers, and wherein the step of solidifying the molten polymers comprises allowing or causing the molten polymers to cool until solid.

19. A method according to Claim 17 wherein the first material and the second material are extruded so that the first material forms a layer over the second material.

20. A method of joining a solidifiable liquid polymeric material to a reinforcement material or a filler, the method comprising the steps of:

contacting a reinforcement material or a filler with a solidifiable liquid polymeric material at an interface between the reinforcement material or the filler and the polymeric material;

applying ultrasonic energy so that the energy reaches the interface between the contacting reinforcement material or filler and the liquid polymeric material; and

forming a joint at the interface by allowing or causing the polymeric material to solidify, to produce a material comprising the solidified polymeric material joined to the reinforcement material or the filler.

21. A method according to Claim 20 comprising a pultrusion process in which the contacting step comprises coating a substantially continuous length of the reinforcement material with the solidifiable liquid polymeric material, and comprising an additional step after the contacting step of drawing the continuous polymeric material-coated reinforcement material through a die to set the desired cross-sectional shape of the resulting composite material, before solidifying the polymeric material.

22. A method according to Claim 20 wherein the contacting step comprises forming a layer of the liquid polymeric material over the reinforcement material.

23. A method of joining a first material to a second material to produce a solid article, the method comprising the steps of:

providing a first material and a second material, where at least one of the first and second materials is a solidifiable liquid material;

providing a solid compatibilizing material or a solidifiable liquid compatibilizing material;

contacting the first material and the second material with the compatibilizing material, to form at least one interface between at least two of the compatibilizing material, the first material and the second material;

applying ultrasonic energy so that the energy reaches the at least one interface; and

forming at least one joint at the at least one interface by allowing or causing the at least one solidifiable liquid material to solidify in contact with the solid compatibilizing material, or by allowing or causing the at least one solidifiable liquid material and the solidifiable liquid compatibilizing material to solidify, to produce a solid article comprising the first material, the second material and the compatibilizing material joined together.

24. A method according to Claim 23 wherein the compatibilizing material has chemical properties intermediate of the first and second materials.

25. A method according to Claim 23 wherein the compatibilizing material is a copolymer.

26. A method according to Claim 23 wherein the first material is more polar than the second material.

27. A method according to Claim 26 wherein the first material is Nylon and the second material is polyethylene.

28. A method according to Claim 27 wherein the compatibilizing material is a copolymer of ethylene and acrylic acid.

29. A method according to Claim 23 wherein the solid article comprises a base of the first material and a relatively thin layer of the second material joined to a surface of the base.

30. A method of joining a solidifiable liquid material to a solid part in an extrusion process to produce a solid article, the method comprising the steps of:

extruding a solidifiable liquid material so that the liquid material contacts a solid part at an interface;

applying ultrasonic energy so that the energy reaches the interface between the contacting liquid material and solid part; and

forming a joint at the interface by allowing or causing the liquid material to solidify, to produce a solid article comprising the solidified liquid material joined to the solid part.